COMMISSIONING OF THE 2MeV ELECTRON COOLER FOR COSY / HESR*

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Abstract

The new electron cooler for COSY was built at BINP, Novosibirsk [1]. The required magnetic field along the electron beam trajectory, straightness of magnetic field lines in the cooling solenoid, good electron gun performance and required voltage at high voltage terminal were achieved. Electron beam commissioning is in progress. Installation of the cooler in the COSY ring and commissioning with proton beam is postponed to the end of 2012. Results from electron beam commissioning at BINP are reported.

INTRODUCTION

Beam cooling with up to 3 A of electron current at up to 2 MeV is expected to boost the luminosity throughout the entire energy range of COSY by counteracting the effects caused by dense targets interacting with the circulating beam [2]. Furthermore, the 2 MeV electron cooler can be used for beam cooling at low energy in the HESR ring in the FAIR project.

The electron beam is guided by solenoidal magnetic field all the way from the electron gun to the collector. This approach is chosen to achieve higher electron density at low effective temperatures to minimise beam cooling time. A cascade transformer provides power to numerous high voltage sections, short solenoids, and the collector inside a pressure vessel filed with SF_6 gas [3].

DESIGN PARAMETERS

Basic parameters of the COSY cooler are listed in Table 1. The length of the cooling section is given by the space available in the COSY ring [4].

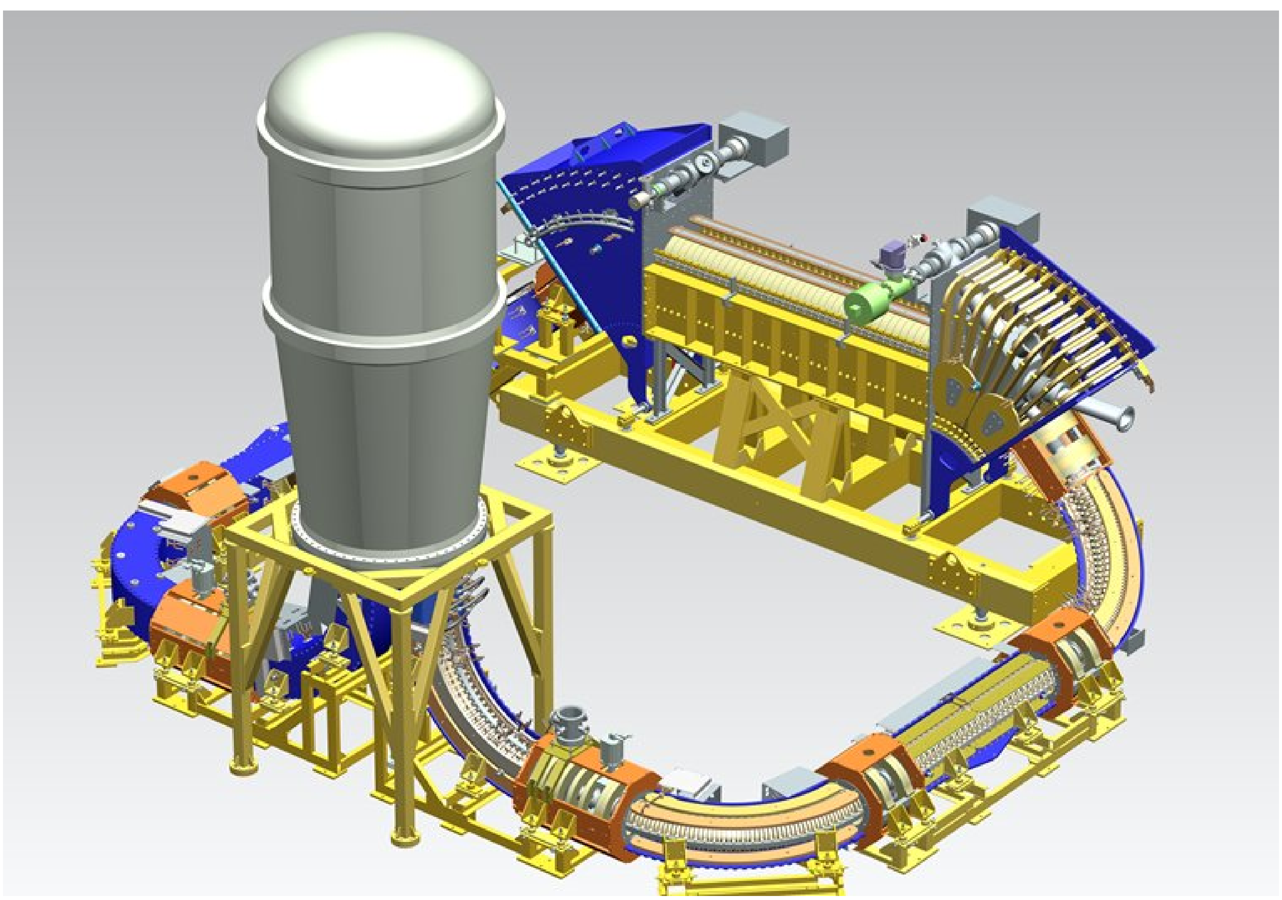

Figure 1: 3D model of the 2 MeV electron cooler for COSY/HESR.

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Table 1: Basic Parameters of the 2 MeV Electron Cooler.

Energy Range	0.025 ... 2 MeV
High Voltage Stability	$< 10^{-4}$
Electron Current	0.1 ... 3 A
Electron Beam Diameter	10 ... 30 mm
Length of Cooling Section	2.69 m
Toroid Radius	1.00 m
Magnetic Field (cooling section)	0.5 ... 2 kG
Vacuum at Cooler	10^{-9} ... 10^{-10} mbar

Performance of the electron collector is crucial for achieving the design parameters. To reduce electron losses from the collector it is equipped with a Wien filter.

MAGNETIC FIELD QUALITY

To satisfy the requirement on the magnetic field straightness in the cooling section ($\Delta\theta < 10^{-5}$), the solenoid is composed of numerous short coils. The horizontal and vertical angles of each coil can be adjusted. After assembling the cooling solenoid the straightness of magnetic field was measured by a system designed solely for this purpose. A laser beam is reflected by a mirror moving along the beam axis inside the solenoid. The mirror is attached to a magnetic rod that aligns itself along magnetic field lines. The mirror support uses jewel bearings and allows very accurate tracking of transverse components of magnetic field. The reflected laser beam is detected with a position sensitive detector. Reflection angle of the laser beam is the measure for the straightness of magnetic field.

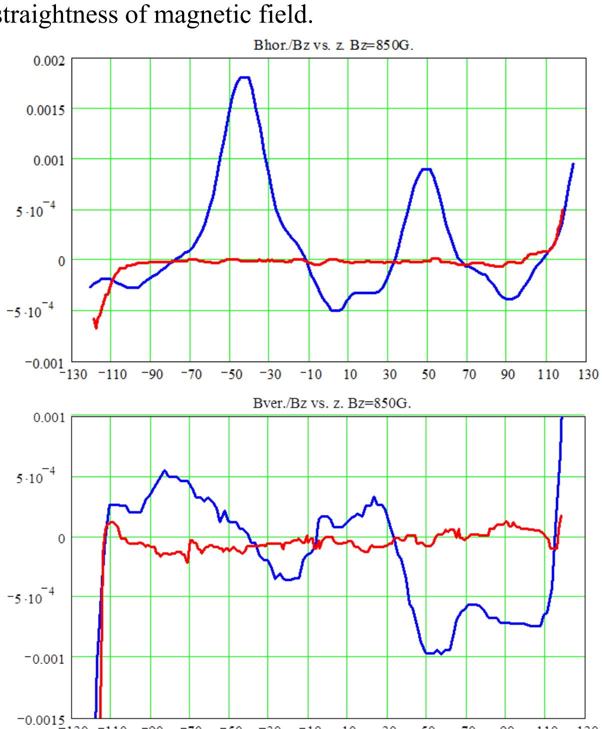

Figure 2: Straightness of magnetic field in the cooling section in horizontal (top plot) and vertical (bottom plot) planes before (blue) and after (red) angle adjustment of the short coils. $B_z = 850$ G.

Fig. 2 shows measured straightness of magnetic field before and after few iterations of mechanical adjustment of the coils. The straightness of magnetic field is expected to change with time. To increase the cooler availability in the COSY ring the magnetic field tracking system is designed to operate in vacuum.

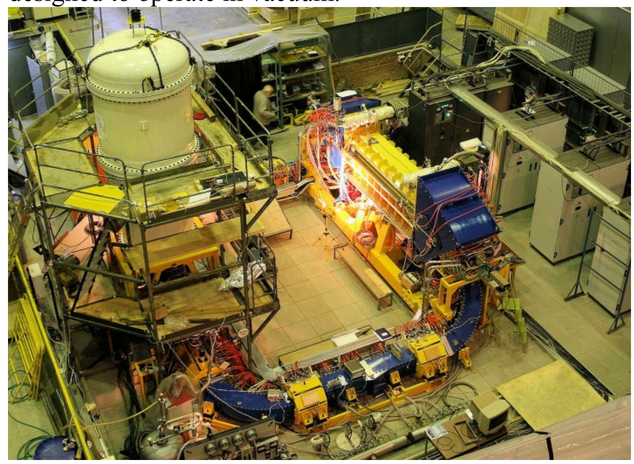

Figure 3: Commissioning of the 2 MeV electron cooler at BINP, Novosibirsk.

Fig. 3 shows the cooler being commissioned at BINP. First tests were performed using local controls. However, at high electron energies the cooler needs to be controlled remotely due to radiation.

HIGH VOLTAGE SYSTEM

Some changes to the high voltage sections were made during commissioning. High voltage feedthroughs had to be replaced due to quality issues. Additional protection circuits were added to prevent damage of electronics in case of high voltage discharge. Special attention was paid to preventing dust particles from settling on critical surfaces during assembling.

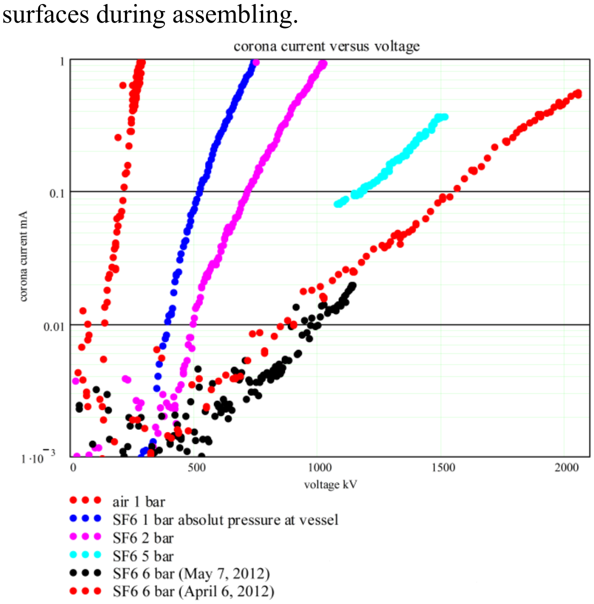

Figure 4: Dependence of corona current on high voltage.

First high voltage tests were done using pressurised air in the high voltage vessel. They were followed by tests using SF_6 gas. 2 MV were demonstrated at 6 bar (absolute) SF_6 pressure after high voltage conditioning. Corona current amounted to 0.5 mA. A decrease of corona current was observed during one month of testing. It is expected to drop further with time and at higher SF_6 pressures. Fig. 4 shows the dependence of corona current on voltage at different air/SF_6 pressures. 7 bar of SF_6 gas in the high voltage vessel appears to be reasonable for long runs. Numerous discharges occurred during recent tests at 2 MV without damaging electronics in high voltage sections. Operation at 1 MV for few weeks without sparking was demonstrated. With electron beam, recuperation breakdowns were observed without causing any additional problems.

ELECTRON BEAM SYSTEM

Electron beam profiles were measured. Fig. 5 shows a beam profile measured by means of a pin detector. Aside from slight emission inhomoginity across the cathode surface presumably due to insufficient activation, the electron gun shows good performance. Measured electron gun perveance agrees well with computer simulations. Tuning the shape of the electron beam profile is done by adjusting the U_{grid}/U_{anode} voltage ratio.

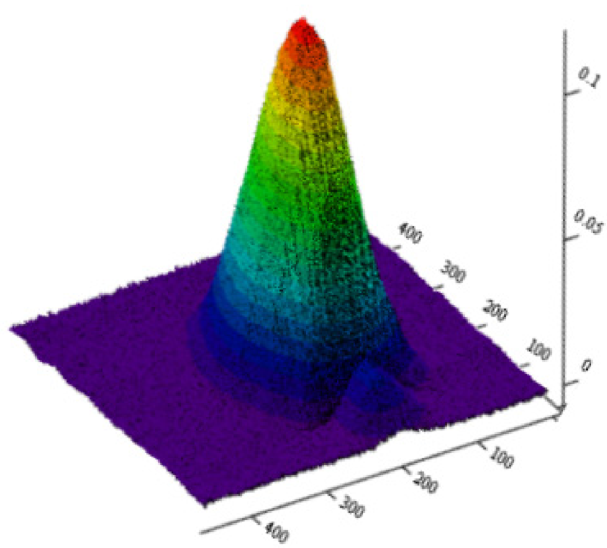

Figure 5: Electron beam profile at $U_{grid} = 0$, $U_{anode} = 500V$. The electron gun operated in pulse mode at very low duty cycle (0.04%) and peak electron currents in the range from 0.1 to 0.5 A.

Electron collector efficiency, being a critical parameter for the overall performance of the cooler, was studied in detail. Fig. 6 shows the dependence of electron beam current, current reflected from collector and leakage current after Wien filter on U_{grid}/U_{anode} ratio. The efficiency of the collector is shown to be better than 10^{-5}.

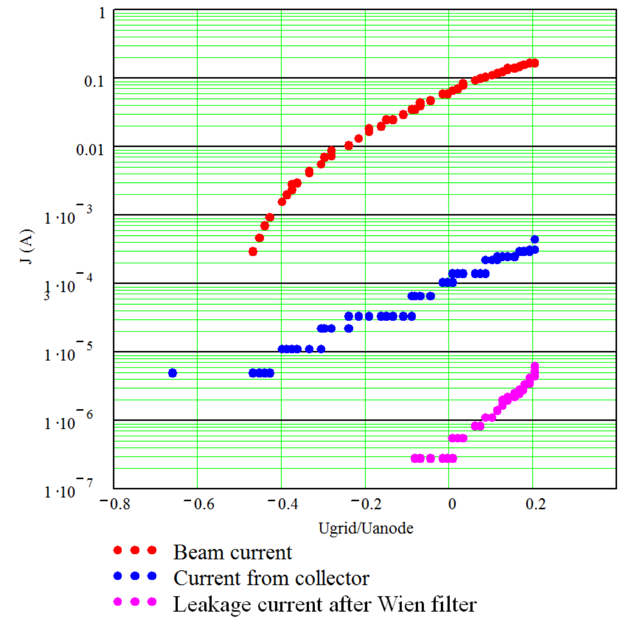

Figure 6: Dependence of electron beam current, current reflected from collector and leakage current after Wien filter on U_{grid}/U_{anode} ratio.

SUMMARY

The design voltage of 2 MV at 6 bar SF_6 pressure was demonstrated. Corona current amounted to 0.5 mA. A decrease of corona current was observed during one month of testing. It is expected to drop further with time and at higher SF_6 pressures. 0.9 A electron beam was established at 30kV. After installing additional protection circuits in high voltage sections, sparking does not damage the electronics. Few weeks of operation at 1 MeV without any sparking is demonstrated. With electron beam numerous recuperation breakdowns occurred. Each time electron beam operation could be re-established immediately. SF_6 pressure of 7 bar appears to be optimal for long term operation of the cooler. Despite good progress made in the past several months, installation of the cooler in the COSY ring and commissioning with proton beam is postponed to the end of 2012.

ACKNOWLEDGMENT

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REFERENCES

[1] V.V. Parkhomchuk, "Development of Electron Coolers in Novosibirsk," these proceedings.
[2] T. Kikuchi et al., "Numerical Study on Simultaneous Use of Stochastic Cooling and Electron Cooling with Internal Target at COSY", IPAC10.
[3] Conceptual Design Report, BINP, Novosibirsk 2009.
[4] J. Dietrich et al., "Progress of the 2 MeV Electron Cooler Development for COSY-JÜLICH/ HESR", COOL11.